Deriving an ocean colour product from measurements of the GOME and SCIAMACHY instruments

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SCIAMACHY ENVISAT ife

Introduction

When solar light interacts with substances present in ocean water (such as phytoplankton, inorganic particles, dissolved organic chemicals, and the water itself), it can either be absorbed, transmitted or reflected. Depending on the properties of the substance, this effect will depend on the wavelength. As a result, the ocean as seen from above changes its colour depending on the dissoveld substances. This effect is know as ocean colour.
The main reason for measuring ocean colour is to study phytoplankton and microscopic plants in the ocean that form the basis of the marine food chain. Ocean colour measurements allow estimates to be made on the amount and types of phytoplankton present in the water. Phytoplankton contains pigments that are necessary for photosynthesis (primarily chlorophyll-a) and their presence changes the colour of the water. The plants actually scatter light while the chlorophyll pigment in the plants absorbs light.
Thus, ocean colour can be used as an indicator for ocean biological productivity and provide information on fishing potentials, climate changes (carbon dioxide sequestration) and also pollution.
The main aim of this work is to try to derive an ocean colour product from SCIAMACHY and GOME measurements and to compare it with the ocean colour derived from SeaWiFS measurements of the water leaving radiance.

Ocean colour measurements

Ocean colour measurements are usually performed with instruments that have high spatial resolution and poor spectral resolution (OCTS, SEAWIFS). Ocean colour is determined by taking ratios of water leaving radiance in spectral regions with and without chlorophyll absorption, and a correction applied for the effect of the atmosphere. High spatial resolution is needed as biological activity in the oceans is highly variable, but also to increase the number of cloud free measurements.

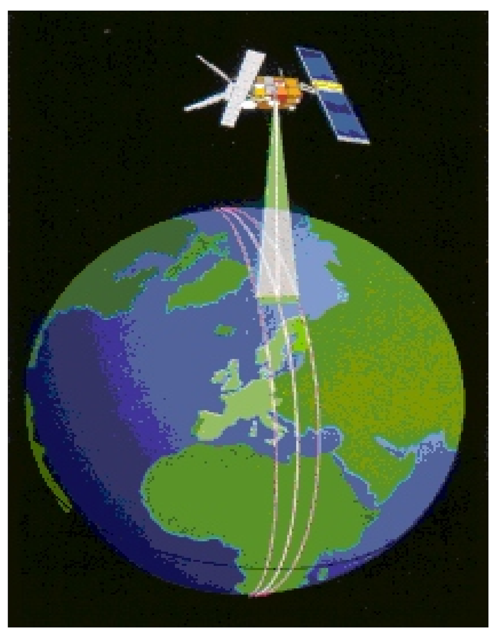
GOME and SCIAMACHY do have much poorer spatial resolution (320 x 40 km2 and 60 x 30km2 as compared to 4.5 x 4.5 for SEAWIFS) and therefore are more affected by clouds. On the other hand, the spectral resolution is much better, and potentially, the measurement can be used to derive information on the type of phytoplankton in addition to just the total amount.

In this study, a first very simple approach was taken by computing the ratio of the sun normalised radiance at the top of atmosphere for two wavelength intervals 425-450 nm and 500-560 nm. No atmospheric correction has been applied.

In a second approach, chlorophyll was identified directly in the spectra by applying a DOAS fit of its absorption cross/section.

GOME and SCIAMACHY instrument

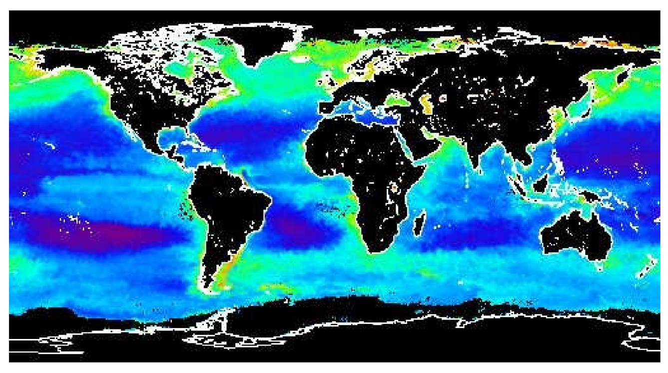
The SCIAMACHY instrument is among the ten sensors onboard of the ENVISAT satellite launched on 1st March 2002 into a sun-synchronous polar orbit and started operation in August 2002. It comprises of 8 channel grating spectrometer measuring in nadir, limb, and occultation (both solar and lunar) geometries.
SCIAMACHY covers the wavelength range between 220 to 2400 nm with a spectral resolution ranging from 0.20 to1.48nm. In this study, only nadir measurement were used in a wavelength range between 400nm to 600nm.The nadir ground-pixels size for most of the major constituents measured by the instrument is 60 x 30 km2 and can be less.

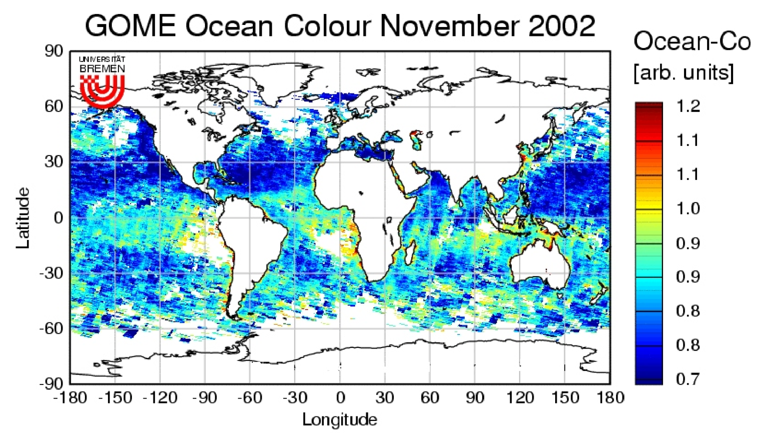


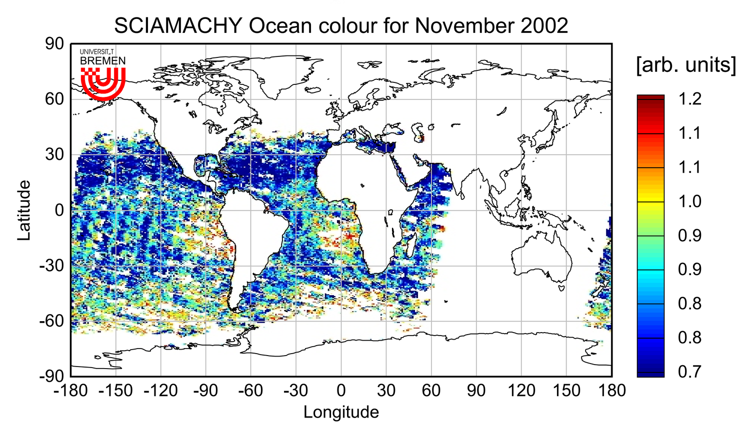
The GOME instrument was launched onboard the ERS-2 satellite on 21st April 1995,into a sun-synchronous polar orbit. It is locate at latitude of 780km with an inclination of 98.7° and the equator crossing time of 10:30am. GOME consist of a four channel grating spectrometer covering wavelengths ranging from 240nm to 790nm with a spectral resolution between 0.2 - 0.4 nm. It provides a global coverage in approximately three days. The mode of operation is mainly in the nadir viewing geometry but the instrument can also view the sun and the moon The standard ground pixel size of GOME is 40 X 320km2

While GOME and SCIAMACHY are similar in many respects, the improved spatial resolution of SCIAMACHY makes it much better suited for measurements of ocean colour.

Results from GOME and SCIAMACHY







In the figures shown on the left side, ocean colour maps derived from SEAWIFS seawifs.gsfc.nasa.gov/SEAWIFS.html (top), GOME (middle) and SCIAMACHY (bottom) measurements are compared for November 2002.

While the SEAWIFS data shown are calibrated chlorophyll concentrations, the GOME and SCIAMACHY maps show uncalibrated colour ratios that can be compared to SEAWIFS only in a qualitative way.

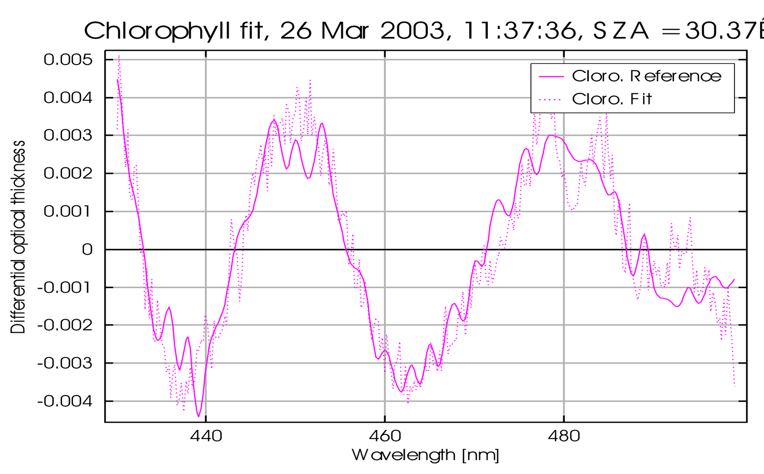
GOME ocean colour qualitatively agrees well with the SEAWIFS measurements, but the effect of poorer spatial resolution is clearly visible.

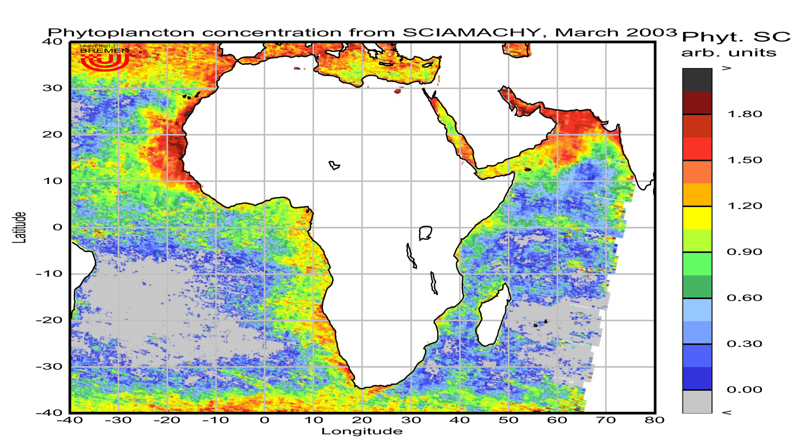
SCIAMACHY ocean colour still differs much from the SEAWIFS data. The main reason for this are calibration problems in the SCIAMACHY spectra that strongly affect the wavelength regions used in the data analysis.

The spatial resolution of the measurements and the missing atmospheric correction also affect the quality of these preliminary ocean colour products,

Results from DOAS analysis

We performed a Differential Optical Absorption Spectroscopy (DOAS) analysis of SCIAMACHY nadir spectra in order to identify and retrieve differential absorption due to phytoplankton. For this, we used a clean mid-atlantic background spectrum at about 20° latitude and chlorophyll cross sections measured in sea water. A typical spectral fit of these cross sections with added residuals is shown in the lower left Figure, demostrating the good fit quality. The retrieved "chlorophyll slant columns" are plotted in the figure on the right, which indicates elevated phytoplankton concentration along the west coast of Africa, as is expected in this region.





Conclusions

- Measurements from the GOME and SCIAMACHY instruments have been used to derive a first simple ocean colour product.
- Comparison with SEAWIFS measurements shows qualitative agreement for GOME data, but still large problems for SCIAMACHY, mainly related to calibration problems in the spectra.
- A new approach has been tested to identify chlorophyll in SCIAMACHY measurements using a DOAS fit of the chlorophyll absorption cross/section. The results are promising and show the potential of instruments with high spectral resolution for the retrieval of chlorophyll concentrations in sea water.

Outlook

- Implementation of an atmospheric correction using SCIATRAN model simulations
- Use of SCIAMACHY spectra with better calibration
- Extension of data analysis to more data

Acknowledgements

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